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MASTER OF MILITARY STUDIES

The Marine Corps F-35B Joint Strike Fighter: Is STOVL the Way Ahead?

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

Major Brian W. Bann
United States Marine Corps

AY 10-11

Mentor and Oral Defense Committee Member: Dr. Paul D. Gelpi
Approved:
Date: 12 April 2011

Oral Defense Committee Member: Dr. Douglas E. Streusand
Approved:
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Author: Major Brian W. Bann, United States Marine Corps

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Discussion: The Marine Corps F-35B Joint Strike Fighter (JSF) Short Take-off and Vertical Landing (STOVL) variant has come under increased scrutiny because it has lagged behind the F-35A and F-35C variants during development test phases. Therefore, the Marine Corps currently faces a significant dilemma on the future direction it will take to support the Marine Air Ground Task Force (MAGTF) with fixed-wing Tactical Aircraft (TACAIR). The Marine Corps took calculated risk by forgoing procurement of any other TACAIR platform besides the F-35B. Critics of the F-35B variant propose that the Marine Corps should procure an additional, or alternate, platform to the F-35B. The proposed alternative platforms to the F-35B weigh differently when comparing support to the MAGTF and risk. This paper analyzes the benefits and risks involved with the Marine Corps procuring single, or multiple, TACAIR platforms. It also provides a detailed examination of STOVL operations and future mission capabilities in order to determine which platform will best support the MAGTF in the future.

Conclusion: The Marine Corps should continue its pursuit for an all STOVL force despite potential program setbacks or political pressure to change. A single TACAIR platform with standardized procedures, streamlined maintenance, and the ability to support any MAGTF mission optimizes an asset and maximizes an opportunity for the Marine Corps. Specifically, no other platform can replicate the diverse STOVL basing options, capabilities of a fifth-generation aircraft, or integration capacity within the MAGTF. The flexibility, efficiency, and interoperability of the F-35B provide the lethal response required to support the future MAGTF in an ever evolving and changing warfare environment. The combined fifth-generation and STOVL capabilities of the F-35B yield the world's most versatile strike-fighter in the history of military aviation; the future success of Marine Corps aviation depends on its incorporation into the MAGTF. Therefore, the Marine Corps should procure solely the F-35B JSF variant, as opposed to augmenting fixed-wing tactical aviation with additional platforms.

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Preface

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Introduction

"We cannot expect the enemy to oblige by planning his wars to suit our weapons; we must plan our weapons to fight war where, when, and how the enemy chooses. The choice of time, place, and circumstances rest with him." [1]

-Vice Admiral Turner Joy, 1952

The Joint Strike Fighter (JSF) program recently has attracted significant attention based on its "substantial cost, ongoing development issues, and its central place in the future of U.S. military aviation."[2] The Marine Corps F-35B Lightning II Short Take-off and Vertical Landing (STOVL) variant has come under increased scrutiny because it has lagged behind the F-35A and F-35C variants during development test phases. In January 2011, Secretary of Defense Robert Gates stated, "I am placing the STOVL variant on the equivalent of a two-year probation. If we cannot fix this variant during this time frame and get it back on track in terms of performance, cost and schedule, then I believe it should be cancelled."[3] Based on the F-35B program setbacks, the Marine Corps currently faces a significant dilemma on the future direction it will take to support the Marine Air Ground Task Force (MAGTF) with fixed-wing Tactical Aircraft (TACAIR).

The Marine Corps took calculated risk by forgoing procurement of any other TACAIR platform besides the F-35B. Critics of the F-35B variant propose that the Marine Corps should procure an additional, or alternate, platform to the F-35B. With the assumption that the JSF program as a whole will not be cancelled, the F-35B alternative platforms being explored include the F/A-18E/F, the F-35C variant, and a light attack aircraft. All of these alternative platforms to the F-35B weigh differently when comparing support of the MAGTF and operational risk. However, none of these alternatives is a versatile platform like the F-35B that enables optimal support, which the MAGTF requires and expects.

A single TACAIR platform with standardized procedures, streamlined maintenance, and the ability to support any MAGTF mission optimizes an asset and maximizes an opportunity for the Marine Corps. No other platform can replicate the diverse STOVL basing options, capabilities of a fifth-generation aircraft, and integration capacity within the MAGTF; therefore, the Marine Corps should procure the F-35B only instead of augmenting fixed-wing tactical aviation with additional platforms, in order to provide unparalleled flexibility, efficiency, and interoperability to the MAGTF. This paper analyzes the benefits and risks involved with the Marine Corps procuring single, or multiple, TACAIR platforms. It provides, as well, a detailed examination of STOVL operations, future mission capabilities, and MAGTF support in order to validate the procurement of the F-35B alone.

The F-35B Joint Strike Fighter Program

The Department of Defense (DOD) initiated the JSF program, as a joint program to provide an affordable fifth-generation strike fighter for the U.S. Air Force, Navy, and Marine Corps. The three services, along with several coalition partners, share development, procurement, and operating costs for the program. The F-35 Lightning II is a single-seat aircraft with advanced stealth characteristics capable of supersonic flight.[4] There are three variants of the F-35, each designed to meet specific requirements in different operating environments. The way the three F-35 variants take off and land is the main difference between them, even though they share 70%-90% commonality.[5] The F-35A Conventional Take-off and Landing (CTOL), designed primarily for the U.S. Air Force, will operate from traditional runways. The F-35C CTOL variant (also known as "CV" variant), designed primarily for the U.S. Navy, will operate from conventional runways and aboard aircraft carriers.[6] Finally, the F-35B STOVL variant will

operate aboard ship and from forward bases with reduced runway length in order to support Marine Corps expeditionary operations.

The Marine Corps procured the F-35B in order to replace an aging fleet of legacy AV-8B, F-18A/B/C/D, and EA-6B fixed-wing aircraft. These aircraft, designated TACAIR platforms, will reach the end of their service life over the next ten years and require a phased-in replacement before their service life ends.[7] The Marine Corps has forgone the procurement of any other TACAIR platform in order to make a long-term investment in the F-35B. The return on investment from reducing three different platforms into one creates excellent cost efficiencies. In summary, the joint nature of the program, combined with reduced logistics, maintenance, and manpower requirements, provides a much more long-term, cost effective platform for the Marine Corps.

While currently in the Developmental Test and Evaluation (DT&E) phase at Naval Air Station (NAS) Patuxent River, Maryland and the F-35B remains scheduled to begin the Operational Test and Evaluation (OT&E) phase in 2011.[8] There are currently four F-35Bs undergoing testing and only one F-35C in the initial phases of DT&E at NAS Patuxent River.[9] In addition, four F-35A variants are flying at Edwards Air Force Base (AFB), California. All three variants are conducting daily developmental test flights and accomplishing required test points. In other words, many unknown variables remain in the testing process in order to validate the F-35B or F-35C and its future capabilities. The Marine Corps expects delivery of the first F-35Bs to Eglin AFB, Florida in the summer of 2011 where the first Fleet Replacement Squadron (FRS) will train pilots and maintenance personnel. The dynamic nature of aircraft testing will most likely lead to changes in these timelines prior to the publication of this paper.

The MAGTF and the All-STOVL Vision

"Individual Marines are the bedrock upon which our Corps was built."
-General James F. Amos, Commandants' Planning Guidance, 2010[10]

Individual Marines are the backbone of the Corps and justify the procurement of the amphibious, ground, and aviation assets to support them. Marines are most effective at providing lethal and responsive combat power on the battlefield when utilizing organic combined arms; thus, the synergistic method in which the Marine Corps integrates air, land, and sea assets to support the individual Marine is crucial to operational success.

Consistent with the concept of support for Marines on the battlefield, the Marine Corps developed a Marine Air Ground Task Force (MAGTF) concept that is comprised of several air, land, and sea assets. The MAGTF, designed to be flexible, maneuverable, and expeditionary, requires aviation assets that can provide immediate organic fire support, no matter what environment Marines find themselves operating in. Marine ground forces are expeditionary in nature and rely heavily on aviation elements to augment organic fires from ground- and ship-based fires that are limited in range, terrain, and mobility.[11] Aircraft that can provide lethal and rapid response in diverse and austere environments are an indispensible asset to the MAGTF. Thus, the Marine Corps fulfills this lethal and rapid requirement by utilizing STOVL aircraft to support the MAGTF.

STOVL capable aircraft provide the MAGTF with flexible basing options, greater survivability, and increased global presence. STOVL aircraft, "with their ability to operate from shorter runways, will reduce the need for conventional runways and their associated arresting equipment. These aircraft must be designed to operate from any combination of expeditionary fields, existing runways, hard surface roads, or sea based."[12] These versatile basing options allow aircraft to base with ground forces and provide rapid response on the battlefield. As a

result, the basing options provide greater survivability through dispersion of forces across the area of operations, forcing the enemy to defend from all locations.

The Marine Corps desires an all-STOVL force for the current and future MAGTFs. This desire was evident in 1957, when the Commandant of the Marine Corps General Pate wrote a letter to the Chief of Naval Operations to advocate the procurement of an all-STOVL force to meet operational mission capabilities as soon as technology made it a viable option.[13] STOVL is a proven concept during combat operations over the past thirty years, especially with the procurement of the AV-8B Harrier and MV-22 Osprey. These aircraft allowed aviation assets to base with ground elements aboard ship and land based in austere environments. Thus, one can infer that an all-STOVL force will provide the Marine Corps with the expeditionary capability required to respond to missions in "any clime and place." Consequently, the only fixed-wing platform that can provide the future MAGTF with an all-STOVL force is the F-35B.

Marine Corps Aviation and the F-35B

Marine Corps aviation focuses on a single battle concept that "exploits the combined arms nature of MAGTF operations" and "allows the MAGTF commander to fight a single battle with an integrated, task-organized force of ground, aviation, and logistic forces."[14] In fact, Marine aviation's "greatest value is in its integrated contribution to the MAGTF's overall mission. It is designed to function most effectively as an integral part of the MAGTF and cannot be separated without a significant loss of capability."[15] As such, a fixed-wing aircraft, such as the F-35B, integrated into the MAGTF and capable of providing rapid organic fires to the ground element, is critical to the combat effectiveness of the Marine Corps.

According to Marine Corps doctrine, the primary focus of Marine Corps aviation is at the tactical level, even though it can contribute to all three levels of war.[16] For example, the fifth-

generation capabilities of the F-35B, such as stealth and advanced networked communications, make it able to contribute to the operational and strategic levels of war. These capabilities combined with the joint design of the F-35B will allow Marine Corps aviation to increase its operational and strategic contributions to warfare. In addition, the F-35B's flexible basing via STOVL technology will increase the number assets that can effect strategic actions which can be deployed aboard various naval platforms and forward bases. Likewise, at the operational level of war, the low observable characteristics and increased range of the F-35B allow it to strike targets that "consist of enemy capabilities or resources whose destruction or neutralization are important to the prosecution of the campaign."[17]

At the tactical level of war, the F-35B contributes by executing five of the six functions of Marine Corps aviation. The six functions include offensive air support, anti-air warfare, electronic warfare, control of aircraft and missiles, aerial reconnaissance, and assault support. The F-35B can execute the first five functions, which provide increased capabilities to the MAGTF. Specifically, the F-35B can simultaneously conduct numerous Marine aviation functions that currently require up to three different legacy platforms. The F-35B will combine the capabilities of VMFA (AW), VMFA, VMA, and VMAQ squadrons into one VMFA squadron that can support the required functions of Marine Corps aviation.[18]

The F-35B can conduct Offensive Air Support (OAS) with longer on-station times for Close Air Support (CAS) and extended ranges for Deep Air Support (DAS) than any legacy Marine Corps aircraft. The F-35B will penetrate Integrated Air Defense Systems (IADS) and escort itself during a strike mission better then any legacy platform in the DOD. Furthermore, the Anti-Air Warfare capabilities during Offensive Anti-Air Warfare (OAAW), or Offensive Counter Air (OCA), increase with stealth technology and the Active Electronically Scanned

Array (AESA) radar. Additionally, the F-35B provides a superior platform to conduct Air Defense, or Defensive Counter Air (DCA), for amphibious ships than the AV-8B. Furthermore, the F-35B provides a superior escort for the V-22 with extended range and greater airborne threat standoff capabilities than the AV-8B.

In addition, fifth-generation sensor fusion, data collection, and communications networks of the F-3B enable real time information sharing with intelligence and Command and Control nodes, which provides Air Reconnaissance support to the MAGTF superior to all legacy systems. The F-35B provides an effective Electronic Warfare (EW) platform for a high threat environment, to include Suppression of Enemy Air Defenses (SEAD) and Destruction of Enemy Air Defenses (DEAD). In the roles of Tactical Air Controller, Air (TAC(A)), Forward Air Controller-Airborne (FAC(A)) and Strike Coordination and Reconnaissance Commander (SCAR(C)) the F-35B conducts control of missiles and aircraft. Although other types of aircraft can conduct these missions, the ability of the F-35B to integrate into the MAGTF and its multi-mission capabilities distinguish it from legacy platforms and other fifth-generation aircraft; thus, the Lightning II stands out as the optimum single TACAIR platform to fulfill the required functions of Marine Corps aviation.

The Discriminators: Why the F-35B?

The F-35B is a unique aircraft designed to capitalize on STOVL technology and multi-mission capabilities. These unique characteristics of the F-35B distinguish it from any other aviation platform in the world. The flexible basing options, numerous efficiencies gained, and interoperability within the Marine Corps are unparalleled discriminators for the F-35B. Even though some aircraft possess these capabilities, none can provide the combined benefits achieved

from a single platform like the F-35B in support of the MAGTF. The three major factors that distinguish the F-35B from any other platform are flexibility, efficiency, and interoperability.

Flexibility

"Flexibly: A general competency defined as being open to change and new information; adapting behavior and work methods in response to new information, changing conditions, or unexpected obstacles; adjusting rapidly to new situations warranting attention and resolution; willingly championing new ideas and methods, despite opposition, when the organizational benefits outweigh the cost."

-Webster's Dictionary[19]

Flexibility is the cornerstone concept behind the Marine Corps operating an all-STOVL force and provides several major advantages to the MAGTF through various basing options and increased survivability. The F-35B's STOVL capabilities provide the flexibility required to support the rapidly changing nature of expeditionary operations without the basing limitations of conventional aircraft.[20] For example, STOVL capabilities permit access to an increased number of runways and naval platforms, allowing the Marine Corps to provide organic fixed-wing fire support to the MAGTF from various locations around the globe. Specifically, the F-35B has the ability to operate from reduced runway environments, various naval platforms, and any normal runway environment that CTOL aircraft use. Increased basing options allow the MAGTF to operate without the requirement for host country access or over-flight support.

Ability to Operate from Reduced Runway Environments

From the Falkland Islands to current operations in Operation Enduring Freedom (OEF), STOVL operations using Harrier aircraft have provided ground and naval commanders multiple basing options unavailable to CTOL fixed-wing aircraft. Much like the Harrier, the F-35B can operate from runway lengths less than 3,000 feet, which increases the number of runways available worldwide by eight times.[21] According to Headquarters Marine Corps (HQMC), there

are less than one-thousand runways greater than 10,000 feet in length and less than five-thousand runways greater than 6,000 feet in length worldwide.[22] Typical fixed-wing aircraft require a minimum of 6,000 feet to safely operate, and most need more runway length when operating with combat loads (increased weight), on wet runways, or from higher density altitudes (less performance). There are over 20,000 runways 3,000 feet in length, which exponentially increases the number of airfield options available for STOVL aircraft to use. Of note, logistical support is also available through C-130 and C-17 (transport/cargo aircraft) when utilizing runways 3,000 to 4,000 feet in length.

In addition to multiple runways available, STOVL aircraft can recover to (land at) airfields with fewer restraints than CTOL aircraft. For example, if a portion of the runway is unusable due to enemy fire or aircraft mishap, STOVL aircraft can recover on portions of the runway or taxiways. AV-8Bs demonstrated this capability during Operation Iraqi Freedom (OIF) at Al Asad Air Base and during OEF at Bagram and Kandahar Air Bases.[23] Airports with runways oriented in a single direction also limit CTOL aircraft crosswind limitations. AV-8B aircraft were also able to land on taxiways off-axis from the main runway when crosswinds were out of limits for CTOL aircraft at these combat air bases[24] In order to use runways shorter than 6,000 feet, aircraft such as the F/A-18 recover to an airfield by using arresting gear. STOVL aircraft do not require the logistical support required for installation of arresting gear at an airfield, or the time required between multiple recoveries via arresting gear. Instead, STOVL technology provides greater flexibility to fixed-wing aircraft when recovering to an airfield requiring less runway length, enabling off-axis landings during extreme crosswinds, and no requirements for arresting gear.

The specific number of available runways around the world varies according to sources cited and the limitations involved with operating fixed-wing aircraft from austere airfields. Some of those limiting factors include Foreign Object Damage (FOD) issues, airfield security, runway environment lighting, and available instrument recovery procedures. Regardless of the inherent limitations to airfield conditions, STOVL basing options increase exponentially compared to that of CTOL aircraft flexible basing options.

Increased flexibility for forward land-based aircraft depends on STOVL capability. For example, over the past thirty years, AV-8A/B Harriers validated STOVL technology by operating from Forward Operating Bases (FOBs) and Expeditionary Airfields (EAFs). In Operation Desert Storm, sixty-six land-based Harrier aircraft operated from the King Abdul Aziz Naval Base and the Tanajib FOB.[25] Each base was closer to Kuwait than any other airfield and reduced the transit time for fixed-wing aircraft to be over the target area. During the initial stages of OIF in 2003, AV-8B aircraft operated from Forward Arming and Refueling Points (FARPS) on Highway 1 (just 70 miles south of Baghdad) and a FOB at An Numaniyah.[26] This capability enabled Harriers to increase the number of sorties flown, decrease the number of tankers required, and be "the most forward deployed aircraft in theatre."[27]

In addition to increased runways available to STOVL aircraft, the Marine Corps has successfully built and sustained FOBs and EAFs for STOVL aircraft to operate from in combat environments. For example, recent operations in OEF at FOB Dwyer and Bastion allowed AV-8Bs, V-22s, and rotary wing aircraft to operate in close proximity to ground forces.[28] In addition, Marine Corps Lieutenant General George J. Trautmen III recently stated "Whether operating from Kandahar's taxiways when the main runway is closed, from FOB Bastion when the winds are 90 degrees off center, or from the short expeditionary airstrip...at FOB Dwyer, the

AV-8B represents precisely the kind of operational game changer the Marine Corps envisions with an all-STOVL Joint Strike Fighter in the future."[29] Basing fixed-wing aircraft at FOBs reduces response time for CAS missions, increases the number of sorties flown, and reduces transit time to the target area.[30] STOVL technology in the F-35B allows the Marine Corps continued use of an aircraft like the Harrier to support the MAGTF of the future.

Ability to Operate from Naval Platforms

STOVL technology also increases sea-basing options available to the F-35B. With the ability to land vertically, the F-35B will operate from various naval ships much like the Harrier does now. The F-35B will be capable of operating from numerous amphibious assault ships, such as the Landing Helicopter, Amphibious (LHA), the Landing Helicopter Dock (LHD), and coalition ships that support STOVL operations. Additionally, the F-35B is capable of operating from Carrier Vessel (CV) ships that CV aircraft operate from via catapults and arresting gear. The U.S. Navy currently has 11 amphibious assault ships and 11 CVs in its inventory that support fixed-wing aircraft operations. Without the F-35B STOVL capability, the Navy and Marine Corps lose fixed-wing air support on 11 of its 22 ships, leaving only 11 CVs with fifth-generation strike-fighters aircraft.

Further increasing the sea-basing options for STOVL aircraft is the fact that amphibious assault ships are flat-bottomed boats, which allows them to operate closer to the shore and littorals than CVs. During OIF, the USS Bonhomme-Richard and USS Battan supported operations with 24 Harriers aboard each ship.[31] These ships, dedicated to strictly fixed-wing STOVL operations, reduced time required between operations with fixed-wing and rotary wing aircraft. These amphibious assault ships, able to operate in shallower water, maximized sortie generation rates because they were further north in the Arabian Gulf than CVs. Numerous sea

basing options available to the F-35 enable fixed-wing assets to operate from various naval ships, increase naval power projection, and improve MAGTF supportability.

The feasibility of STOVL aircraft operating simultaneously with CV aircraft is a topic often debated between the Marine Corps and the Navy. Critics of STOVL integration aboard CVs argue that mixed operations complicate operations, despite positive reports from previous mixed operation deployments. AV-8A and B aircraft successfully proved mixed STOVL and CV operations were feasible when they deployed and operated from the USS Franklin D. Roosevelt and USS Kitty Hawk.[32] An After Action Report from these deployments cited that: "The AV-8(A/B) can operate on the CV without impacting normal ops.(operations) and can take advantage of times within the normal deck cycle unusable to other CV aircraft."[33] Unlike the combination of AV-8B Harriers and different platforms aboard CVs, the commonalities between the F-35B and C variants will reduce logistic and maintenance requirements.

STOVL operations aboard ship, whether integrated with CVs or not, provide increased flexibility and efficiencies. STOVL operations require less maneuver space for ships, reduce manpower requirements, and cost less than CV operations. STOVL aircraft, since they are landing vertically, do not require a ship to create wind over the deck like CV aircraft. Therefore, ships conducting STOVL operations do not require as much maneuver space as CV operations. STOVL aircraft can also launch and recover outside the normal catapult and arrestment window, allowing for longer flight operations with less manpower requirements to operate the flight deck. In addition to increased flight operations aboard a CV, boarding rates of STOVL aircraft (nearly 100%) are typically better than that of CV aircraft aboard ship, which reduces the overall recovery window and increases efficiency aboard ship.[34] Training of aircrew to conduct STOVL operations aboard ship is also less complicated then CV carrier qualifications, which creates cost,

time, and manpower efficiencies. Lastly, amphibious assault ships are cheaper to build and operate then CVs, ranging from $1 billion to $10 billion, respectively.[35] Considering the advantages of STOVL capabilities, the F-35B provides more flexibility and efficiency to the MAGTF than CV aircraft are capable of providing.

The flexible nature of STOVL operations also increases MAGTF survivability and lethality. Dispersion of aviation assets across the area of operations increases survivability. Likewise, basing aviation assets at FOBs and aboard various ships reduces the strategic value of large airfields and CVs. Dispersion of aviation assets at numerous locations reduces the risk of aircraft susceptible to attack at these strategic locations. In addition to increased survivability, STOVL basing options improve lethality because they allow access to multiple avenues of approach to attack the enemy. Multiple avenues of approach, available with STOVL basing options, force the enemy to defend a larger area and increase the ability of the MAGTF to conduct maneuver warfare when attacking. Sun Tzu referenced the maneuver warfare concept when he stated, "Speed is the essence of war. Take advantage of the enemy's unpreparedness; travel by unexpected routes and strike him where he has taken no precautions."[36]

The unique STOVL characteristics of the F-35B allow it to adapt to a modern and evolving battlefield environment, while the flexible basing options permit it to operate in changing conditions that no other platform can. Additionally, F-35B capabilities will be proliferated across a wide spectrum of locations with the ability to integrate STOVL technology into CV and amphibious assault ship operations. Overall, the flexibility of the F-35B will provide organizational and warfighting benefits that outweigh the cost when compared to CV or CTOL aircraft. Therefore, if the Marine Corps and Navy do not exploit the tactical benefits gained by procurement of the F-35B, they stand to lose an unparalleled future capability.

Efficiency

"Efficiency: Measure of the relative amount of resources used in performing a given unit of work. Sometimes characterized as doing things right. Can involve unit costing, work measurement (standard time for a task), labor productivity (ratio of outputs to labor inputs), and cycle time."

-Webster's Dictionary[37]

Efficiency is synonymous within the Marine Corps culture. The Marine Corps has a reputation of "doing more with less" when it comes to manpower, equipment, and budget constraints. In 2010, the Marine Corps consumed only 8.5 % of the DOD budget, while providing the Nation 31% of ground operating forces, 12% of fighter/attack aircraft, and 19% of attack helicopters.[38] The combined arms MAGTF embraces the concept of efficiency by using a light infantry force with limited assets to provide lethal combat power that no other service replicates. Keeping in line with this concept, the Marine Corps has made a calculated risk by forgoing procurement of any other TACAIR platforms until the F-35B is procured, relying on a return investment of long term efficiency. Procuring only the F-35B will provide savings in manpower, equipment, time, and money. Many DOD decisions are (and will continue to be) based on these types of efficiencies. For that reason, future decisions on the F-35B program should factor in efficiencies in terms of combat power, logistics, and training.

Combat Power

STOVL basing options permit aircraft to be closer to the battle space in order to provide efficient support to the MAGTF. Aircraft operating at a closer range have less distance to travel, which equates to more time over the target and less transit time from bases further away. Less transit time equates to an increase of sorties when STOVL aircraft operate closer to the battle space than CTOL aircraft. Therefore, STOVL aircraft can arrive overhead in minimal time, expend required ordnance, then quickly return to re-arm and fly another sortie. Additionally,

STOVL aircraft can launch from a ground alert posture at FOBs and be overhead in minutes to provide rapid and lethal responsiveness for the MAGTF. In contrast, CTOL aircraft operating from CV's and traditional airfields have longer transit times and provide a less rapid response to the MAGTF. For example, in Operation Desert Storm, AV-8B Harriers flew sorties from FOBs located less than 40 miles from Kuwait, enabling increased sortie rates and longer on-station times than other coalition aircraft. General Norman Schwarzkopf recognized the AV-8B as one of the three aviations weapons platforms (including the F-117 and AH-64) that contributed to the quick success of the coalition.[39]

Table 1: F-35 Key Performance Parameters (KPPs)

Source: Jerimiah Gertler, F-35 Joint Strike Fighter (JSF) Program: Background and Issues for Congress. CRS Report for Congress, September 23, 2010, 50.
Notes: PAA is primary authorized aircraft (per squadron); vertical lift bring back is the amount of weapons with which plane can safely land.

Source of KPP	KPP	F-35A Air Force CTOL version	F-35B Marine Corps STOVL version	F-35C Navy carrier-suitable version
Joint	Radio frequency signature	Very low observable	Very low observable	Very low observable
	Combat radius	590 nm Air Force mission profile	450 nm Marine Corps mission profile	600 nm Navy mission profile
	Sortie generation	3 surge / 2 sustained	4 surge / 3 sustained	3 surge / 2 sustained
	Logistics footprint	< 8 C-17 equivalent loads (24 PAA)	< 8 C-17 equivalent loads (20 PAA)	< 46,000 cubic feet, 243 short tons
	Mission reliability	93%	95%	95%
	Interoperability	Meet 100% of critical, top-level information exchange requirements; secure voice and data		
Marine Corps	STOVL mission performance – short-takeoff distance	n/a	550 feet	n/a
	STOVL mission performance – vertical lift bring-back	n/a	2 x 1K JDAM, 2 x AIM-120, with reserve fuel	n/a
Navy	Maximum approach speed	n/a	n/a	145 knots

Aviation history has proven that sortie generation is more important in the initial days of a conflict than time on station. The F-35B has a Key Performance Parameter (KPP) to provide four surge sorties and three sustained sorties, whereas, the F-35A/C are only required to provide three surge and two sustained (See Table 1).[40] Critics of the F-35B argue that it does not have the range or payload capabilities of the F-35A/C. The Marine Corps is willing to accept these limitations to trade for STOVL capability that allows basing options closer to the battle space, which yield a higher sortie generation rate and a more efficient utilization of the F-35B. Higher sortie generation rates coupled with STOVL basing options make the F-35B an extremely efficient platform to support the MAGTF.

Logistics

Intelligent military leaders understand that efficient logistic planning and support equal success on the battlefield. Creating efficiencies through reduced logistical requirements lead to more effective combat power. Therefore, forward based fixed-wing aircraft allow aircraft to return to base, hot refuel, and then return to the fight, instead of using aerial tankers. In addition, aircraft can launch from strip alert to respond rapidly from the forward base instead of flying continuous coverage overhead. Therefore, STOVL aircraft that base closer to the fight drastically reduce the amount of aerial refueling tankers required to support the MAGTF. Typical legacy aircraft (F/A-18, F-16, and F-15E) require large amounts of fuel to provide on station time and typically require an aerial refueling every 45-60 minutes, depending on location of the tanker and the airfield they are recovering to. The F-35B can also carry more internal fuel than legacy USMC platforms, providing greater on station time, which once again results in less tankers required. The cost savings from reducing the amount of fuel and manpower required to aerial refuel fixed-wing jets is an efficiency that benefits the DOD.

Utilizing forward basing options with the F-35B also reduces logistic requirements. FOBs require a less significant logistical footprint than large airfields with numerous aircraft based at them. Small FOBs, roadways, or portions of a runway take less time and effort to prepare, maintain, and operate. These basing options only require support for a short period, prior to establishment of another location closer to battle space. The use of forward bases can also allow more fixed-wing assets to be in theater when ramp space is crowded at larger airfields, as coalition forces currently face in OEF.[41] Therefore, STOVL basing capabilities of the F-35B will enable a lighter, more efficient MAGTF in the future.

Training

In addition to combat efficiencies gained, the F-35B provides Marine Corps fixed-wing aviation with significant efficiencies in training, manpower, and logistical support requirements. One billion dollars is the estimated long-term cost savings from combining three different airframes into a single airframe.[42] A single TACAIR platform drastically reduces requirements to train aviators and maintainers on three different aircraft. Combining numerous training locations, types of simulators, and maintenance schools into one pipeline creates cost savings across the Marine Corps. The TACAIR shops at Marine Aviation Weapons and Tactics Squadron (MAWTS-1) and different TACAIR manpower requirements at HQMC can be combined to create more efficient departments. Additionally, one support structure for aircraft parts, support equipment, and engine repair shops reduces the logistical and maintenance effort required for the F-35B. Consequently, a single TACAIR platform creates efficiencies across a wide spectrum of requirements for Marine Corps aviation.

A single fleet of F-35Bs will create a more efficient and homogenous community of TACAIR pilots in the Marine Corps. Marine TACAIR pilots will no longer be separate cultures

of F/A-18 Hornet, AV-8B Harrier, or EA-6B Prowler pilots. A more standardized F-35B community will operate with similar tactics, techniques, and procedures (TTPs). The "corporate knowledge" across the fleet will undoubtedly lead to better-trained, equipped, and professional aviators able to support the MAGTF of the future. Every F-35B pilot will be able integrate into the MAGTF as part of the Air Combat Element (ACE), regardless of location or ship that aircraft operate from. Historically, the only fixed-wing aviators that were able to integrate fully into a Marine Expeditionary Unit (MEU) were AV-8B pilots that deployed aboard amphibious ships and at forward bases. A homogenous F-35B fleet will no longer have Marine TACAIR squadrons and pilots that can only support the MAGTF from joint airfields or CVs.

The results of these combat and garrison efficiencies are increased sortie generation, a reduced logistical footprint, and economical training and manpower requirements. These efficiencies reduce costs, increase labor productivity, and reduce time inputs required. Efficiency and affordability are common themes across the board when implementing the F-35B into the MAGTF, which happens to align well with the current budget cuts and restrictions the Marine Corps is facing.

Interoperability

"Interoperability: A property referring to the ability of diverse systems and organizations to work together (inter-operate). The term is often used in a technical systems engineering sense, or alternatively in a broad sense, taking into account social, political, and organizational factors that impact system to system performance."

-Webster's Dictionary[43]

The interoperable nature of the F-35B is evident in its ability to integrate into the MAGTF and joint operations. The MAGTF, much like the definition of interoperability states, is a combination of diverse systems and organizations working synergistically to provide flexible and efficient combined arms on the battlefield. Aside from the AV-8B, the F-35B is the only

fixed-wing platform that can fully integrate into the MAGTF. Procurement of solely the F-35B provides the MAGTF with an interchangeable fixed-wing platform that can support any mission requirement. Additionally, the commonalities among the F-35 variants permit the F-35B to integrate easily into joint operations.

A single fleet of F-35Bs, as opposed to a mixed fleet with additional platforms, provides Marine Corps aviation with increased interoperability. The Marine Corps will have twenty-one active component F-35B VMFA squadrons all capable of supporting the same missions.[44] In theory, any squadron of F-35Bs can now support a MEU, Unit Deployment Program (UDP), or TACAIR Integration (TAI) with the Department of the Navy.[45] The F-35B community will be interchangeable across all TACAIR missions and able to spread-load required deployments. Currently, there are only seven AV-8B squadrons able to support seven MEUs in addition to deployments in support of OIF/OEF, forcing a high operations tempo and limited use of assets. The Marine Corps will now have twenty-one squadrons that can support a MEU and forward base in a STOVL environment. Similar to VMFA mission capabilities, F-35B pilots and maintainers will be interoperable across the fleet. VMFA personnel will be interchangeable between any Marine Air Wing (MAW) or Marine Air Group (MAG) that has F-35s, which provides HQMC with flexible and interoperable manpower assignments.

In addition to integration into the MAGTF, the commonalities of the three F-35 variants provide increased interoperability in the joint and coalition environments. Standardized TTPs among aviators and common logistic requirements will allow for seamless interoperability among the three services during a joint campaign and with partner nations during training and coalition operations. The F-35B will also be able to operate from more locations than any other

fixed-wing aircraft, providing the joint commander with the most interoperable and versatile aircraft in the DOD inventory.

One of the most important ways that STOVL technology permits interoperability is through the basic culture and mentality of a Marine Corps fighting force. The MAGTF concept of Marines living, training, and fighting together provides a lethal force that no other service is capable of replicating. MAGTFs, especially MEUs, are an integrated team that understands each other's missions and how each element of the MAGTF compliments the other. The Ground Combat Element (GCE) and ACE harness the true synergy of combined arms when they plan, brief, execute, and de-brief together. Distorted communication can occur without direct support assets attached to the MAGTF, which increases friction on the battlefield. The integrated MAGTF concept provides a perfect venue for organic fire assets to have face-to-face communication, use familiar equipment, and fight with combined arms.

The culture and system integration of the MAGTF provide an extremely interoperable force. The interoperability, efficiencies, and flexibly of the F-35B provide the MAGTF with a lethal responsiveness on the battlefield irreplaceable by any other platform. Sole procurement of the F-35B facilitates a homogenous fleet of F-35Bs that support MAGTF requirements. Lastly, the F-35B provides true interoperability within the MAGTF organization and throughout Marine Corps culture.

Alternatives to the F-35B Program

Flexibility, efficiency, and interoperability provide compelling reasons for the sole procurement of the F-35B and its importance to the MAGTF; however, the counterargument to procurement of a single platform is the risk involved in doing so. Cancellation of the F-35B program or significant delays in testing could force the Marine Corps to acquire or develop an

alternative fixed-wing platform. The risk involved in relying on a single platform (F-35B) that has not completed testing is high for the Marine Corps. Acquiring a secondary platform that will augment the F-35B fleet would mitigate this risk. Significant delays in the F-35B program will force retirement of legacy aircraft prior to the standing up of new F-35B squadrons, creating a large gap of fixed-wing aircraft available to support the MAGTF. The F-35B alternatives, or additional platforms, being explored by HQMC or via independent research methods include a light attack aircraft, the F/A-18E/F Super Hornet, and the F-35C CV variant.

Light attack alternative platforms include the AT-6B Texan, the A-29 Super Tucano, and the OV-10X Bronco.[46] Each of these aircraft provides a cheaper and more persistent platform in a permissive low-threat environment. These aircraft could potentially fill a wide gap between multimillion dollar fifth-generation strike-fighters and rotary-wing aircraft in the CAS environment, reducing cost in systems, logistics, and training. The Marine Corps has already incorporated systems like Harvest Hawk into the KC-130J, which contribute to the CAS requirements in a permissive environment.[47] The light attack platform mentioned and the KC-130 are capable of operating from FOBs with runways 3,000 feet in length or less.[48]

The F/A-18E/F Super Hornet is a proposed platform to augment the F-35B fleet while the transition occurs. Procuring F/A-18E/Fs could alleviate the process of extending service life of legacy FA-18s and reduce the risk of having a TACAIR shortfall during the F-35B transition. The U.S. Navy plans to keep the F/A-18E/F integrated into its Carrier Air Wings (CAW) over the next ten to fifteen years while they transition to F-35Cs.[49] The F/A-18E/F is comparable in range, endurance, and payload to the F-35B, but lacks the true fifth-generation capabilities. F/A-18E/Fs could be incorporated into the current Marine Corps F/A-18 fleet and provide a cheaper short-term alternative to the F-35B.[50]

A more likely alternative than the F/A-18E/F is the F-35C CV variant. The F-35C has a longer combat radius and heavier payload capabilities than the F-35B (See Table 1).[51] The F-35C exceeds the tactical requirements the Marine Corps desires and is capable of CV and EAF operations (with arresting gear). Procuring a combination of F-35Bs and F-35Cs provides risk mitigation if problems occur with the F-35B after testing in an operational environment. A mixed F-35 fleet would be similar to the way Marine TACAIR operates today. Other benefits gained from a mixed F-35 fleet are; increased joint integration with the US Navy, the TACAIR Integration (TAI) commitment fulfilled, and the potential to reduce manpower requirements by combining F-35C Fleet Replacements Squadrons (FRS) with the U.S. Navy.[52] The Navy is publicly opposed to STOVL integration aboard CVs and would most likely support a mixed fleet of Marine Corps F-35Bs and F-35Cs. However, the F-35C is even earlier in its DT test phases than the F-35B; therefore, the risk in procuring this aircraft could increase as well if both programs are delayed.[53]

The risk incurred by the Marine Corps "putting all of its eggs into one basket" with the F-35B program is high. If the F-35B program fails or is cancelled, the Marine Corps will be stuck without a TACAIR platform to support the MAGTF. These alternative platforms mentioned provide risk mitigation, and in some cases a cheaper alternative. Augmenting the F-35B fleet would be ideal over cancelling it in favor of another platform. The optimum solution to augment the F-35B fleet is a combination of F-35Bs and F-35Cs, as opposed to dissimilar platforms.

Even though each of these alternative platforms provides risk mitigation, none of them provide the Marine Corps with STOVL basing options and the ability for the Marine Corps to homogenize its TACAIR fleet. Combinations of the F-35B and an additional platform might

fulfill Marine Corps mission requirements, but would involve more training, maintenance, and logistics efforts to sustain a second platform, which is especially true with the procurement of a light attack platform or the F/A-18E/F. Neither platform possesses fifth-generation capabilities, which makes survival in a high threat environment more challenging. None of these alternative platforms has STOVL capability, which reduces flexibility and does not support an all-STOVL force for the Marine Corps. A mixed force of F-35Bs and F-35Cs does not provide the Marine Corps with an all-STOVL capability nor does it allow for a homogenized TACAIR community. Sole procurement of the F-35B is the only way to provide the MAGTF with flexible, efficient, and interoperable support.

The Way Ahead: STOVL

The Marine Corps has been a leader in innovative tactics and technology ever since its inception. This visionary mindset allowed the Marine Corps to adapt to evolving warfare environments and truly be able to fight in "any climb and place" over the past two-hundred years. The acquisition and purchase of the AV-8A from the United Kingdom in the 1970s is just one example of the Marine Corps' willingness to make decision based on combat capabilities over political influence.[54] The AV-8A eventually matured into the successful AV-8B program that has provided the inspiration for the F-35B STOVL variant. The Marine Corps has validated the use of STOVL aircraft to provide maximum support the MAGTF at FOBs and aboard amphibious ships. With the technology available today, there is no doubt that the F-35B will be able to meet or exceed the STOVL capabilities that the AV-8B currently offers.

From an economic perspective, the sole procurement of the F-35B for the Marine Corps nets the most gains achieved from a single platform. Like all entrepreneurships

(new aircraft procurement), there is risk involved. The benefits gained from an all-STOVL fleet of F-35Bs outweigh the risk involved. None of the proposed alternatives to the F-35B provides an all STOVL force with fifth-generation capable TACAIR support available to the MAGTF. The JSF program has billions of dollars invested into it; it is doubtful that the DOD will let it fail. It will be incumbent upon Marine Corps leadership, aviators, and maintenance personnel to prevent failure of the F-35B program in the future.

The Marine Corps should continue its pursuit for an all STOVL force despite potential program setbacks or political pressure to change. The flexibility, efficiency, and interoperability of the F-35B provide the lethal response required to support the future MAGTF in an evolving and changing warfare environment. Warfare, which is inherently unpredictable in the types of conflicts fought and locations where it will occur, requires an adaptable and responsive aircraft like the F-35B to support the MAGTF. Therefore, the Marine Corps should procure solely the F-35B and avoid procuring additional platforms to augment fixed-wing aviation. The combined fifth-generation and STOVL capabilities of the F-35B yield the world's most versatile strike-fighter in the history of military aviation; the future success of Marine Corps aviation depends on its incorporation into the MAGTF.

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18. Explanation of TACAIR Marine Squadron identifiers: VMFA = Marine Fighter Attack Squadron (F/A-18 A/C), VMFA(AW) = Marine Fighter Attack Squadron, All Weather (F/A-18D), VMA = Marine Attack Squadron (AV-8B), VMAQ = Marine Electronic Attack Squadron (EA-6B). VMFA squadrons with F-35Bs broaden the range of missions that a single type of aircraft can accomplish, reducing the need for multiple platforms and joint assets required to support multiple missions.
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